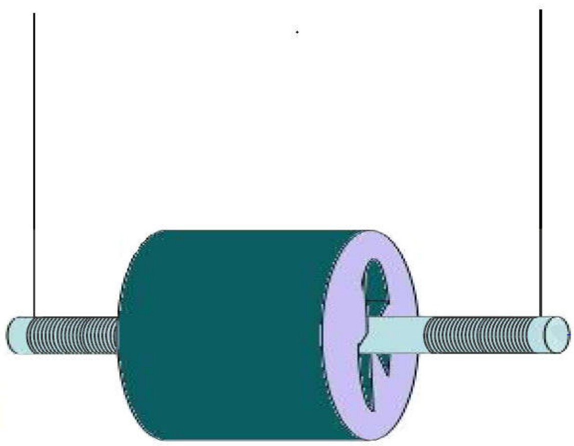
La roue de maxwell



Présenté par les étudiants :

Ould cherchali hocine

➢ Matériels :

- Base de support.
- Tige du support.
- Bloc ou vis de fixation.
- Règle métrique.
- Une paire d'indicateur.
- La roue de maxwell.
- Dispositif de support avec câble de déclanchement.
- Deux fils de connections.

➢ Partie théorie :

On a la relation :

$$E_T = E_{potentielle} + E_{translation} + E_{rotation}$$

$$E_T = m.\vec{g}.\vec{s} + \frac{1}{2}m\vec{v}^2 + \frac{1}{2}I_z\vec{\omega}^2$$

m : la masse de disque

g : accélération de gravitation

s : hauteur

v : vitesse de translation

I : moment d'inertie

ω : vitesse angulaire

D'après l'energie total est constante (conservation),alors

$$\frac{dE}{dt} = -m.g.v(t) + \left(m + \frac{I}{r^2}\right).v(t).\frac{dv}{dt} = 0$$

Manipulation

- En calcule t_{moy} et s_{moy} $tel\ que$

$$t_{moy} = \frac{t_1 + t_2 + t_3}{3} \quad et \quad s_{moy} = \frac{s_1 + s_2 + s_3}{3}$$

- En calcule les incertitudes

Pour la distance "Δh" on a :

$$\Delta s = \Delta s_{inst} + \Delta s_{lecture} + \Delta s_{mesure}$$

$$\Delta s_{inst} = 0.5mm \ ,\Delta s_{lecture} = 0.5mm \ ,\Delta s_{mesure} = max|s_i - s_{moy}|$$

Pour le temps "δt":

$$\delta t = \delta t_{inst} + \delta t_{lecture} + \delta t_{mesure}$$

$$\delta t_{inst} = 0.01s \ ,\delta t_{lecture} = 0\ s \ ,\delta t_{mesure} = max|t_i - t_{moy}|$$

Pour le temps "Δt":

$$\Delta t = \Delta t_{inst} + \Delta t_{lecture} + \Delta t_{mesure}$$

$$\Delta t_{inst} = 0.001s \ ,\Delta t_{lecture} = 0\ s \ ,\Delta t_{mesure} = max|t_i - t_{moy}|$$

Application numérique :

$\Delta s_1 = 0.2 \times 10^{-2} m$

$\Delta s_{inst} = 0.5mm \ ,\Delta s_{lecture} = 0.5mm \ ,$

$\Delta s_{mesure} = max|s_i - s_{moy}| = 0.1 \times 10^{-2} m$

$\delta t_1 = 0.25s$

$\delta t_{inst} = 0.01s \ ,\delta t_{lecture} = 0\ s \ ,$

$\delta t_{mesure} = max|t_i - t_{moy}| = 0.24s$

$\delta \Delta t_1 = 0.005s$

$\delta \Delta t_{inst} = 0.001s \ ,\delta \Delta t_{lecture} = 0\ s \ ,$

$\delta \Delta t_{mesure} = max|t_i - t_{moy}| = 0.004s$

$\Delta s_2 = 0.3 \times 10^{-2} m$

$\Delta s_{inst} = 0.5mm \ ,\Delta s_{lecture} = 0.5mm \ ,$

$\Delta s_{mesure} = max|s_i - s_{moy}| = 0.2 \times 10^{-2} m$

$\delta t_2 = 0.03s$

$\delta t_{inst} = 0.01s$, $\delta t_{lecture} = 0\ s$,

$\delta t_{mesure} = max|t_i - t_{moy}| = 0.02s$

$\delta\Delta t_2 = 0.002s$

$\delta\Delta t_{inst} = 0.001s$, $\delta\Delta t_{lecture} = 0\ s$,

$\delta\Delta t_{mesure} = max|t_i - t_{moy}| = 0.001s$

$\Delta s_3 = 0.3 \times 10^{-2}m$

$\Delta s_{inst} = 0.5mm$, $\Delta s_{lecture} = 0.5mm$,

$\Delta s_{mesure} = max|s_i - s_{moy}| = 0.2 \times 10^{-2}m$

$\delta t_3 = 0.14s$

$\delta t_{inst} = 0.01s$, $\delta t_{lecture} = 0\ s$,

$\delta t_{mesure} = max|t_i - t_{moy}| = 0.13s$

$\delta\Delta t_3 = 0.001s$

$\delta\Delta t_{inst} = 0.001s$, $\delta\Delta t_{lecture} = 0\ s$,

$\delta\Delta t_{mesure} = max|t_i - t_{moy}| = 0.000s$

$\Delta s_4 = 0.2 \times 10^{-2}m$

$\Delta s_{inst} = 0.5mm$, $\Delta s_{lecture} = 0.5mm$,

$\Delta s_{mesure} = max|s_i - s_{moy}| = 0.1 \times 10^{-2}m$

$\delta t_4 = 0.05s$

$\delta t_{inst} = 0.01s$, $\delta t_{lecture} = 0\ s$,

$\delta t_{mesure} = max|t_i - t_{moy}| = 0.04s$

$\delta\Delta t_4 = 0.001s$

$\delta\Delta t_{inst} = 0.001s$, $\delta\Delta t_{lecture} = 0\ s$,

$\delta\Delta t_{mesure} = max|t_i - t_{moy}| = 0.000s$

$\Delta s_5 = 0.3 \times 10^{-2}m$

$\Delta s_{inst} = 0.5mm$, $\Delta s_{lecture} = 0.5mm$,

$\Delta s_{mesure} = max|s_i - s_{moy}| = 0.2 \times 10^{-2}m$

$\delta t_5 = 0.16s$

$\delta t_{inst} = 0.01s$, $\delta t_{lecture} = 0\ s$,

$\delta t_{mesure} = max\left|t_i - t_{moy}\right| = 0.15s$

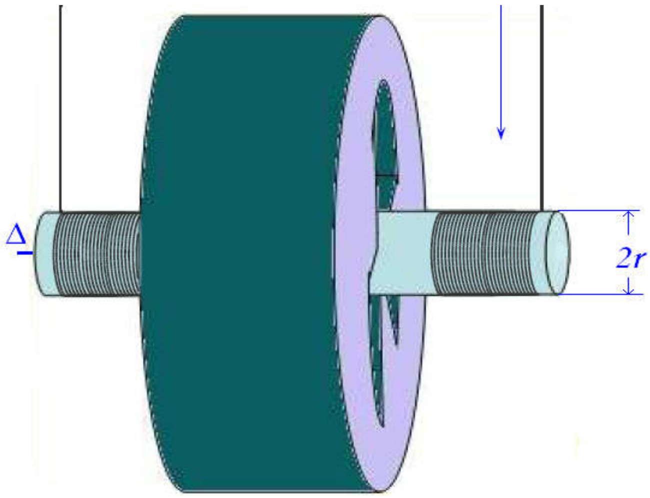
$\delta \Delta t_5 = 0.002\,s$

$\delta \Delta t_{inst} = 0.001s$, $\delta \Delta t_{lecture} = 0\ s$,

$\delta \Delta t_{mesure} = max\left|t_i - t_{moy}\right| = 0.001s$

❖ En calcule les vitesses moyennes et l'incertitude ΔV:

$V_{moy} = \frac{s_{moy}}{t_{moy}}$ $\qquad r = 2.5mm$



$$V_{1\ moy} = \frac{s_{1\ moy}}{t_{1\ moy}} = \frac{27.3 \times 10^{-2}}{4.54} = 6.01 \times 10^{-2} m/s$$

$$V_{2\ moy} = \frac{s_{2\ moy}}{t_{2\ moy}} = \frac{41.1 \times 10^{-2}}{5.54} = 7.41 \times 10^{-2} m/s$$

$$V_{3\ moy} = \frac{s_{3\ moy}}{t_{3\ moy}} = \frac{48.0 \times 10^{-2}}{6.26} = 7.66 \times 10^{-2} m/s$$

$$V_{4\ moy} = \frac{s_{4\ moy}}{t_{4\ moy}} = \frac{37.9 \times 10^{-2}}{5.29} = 7.16 \times 10^{-2} m/s$$

$$V_{5\ moy} = \frac{s_{5\ moy}}{t_{5\ moy}} = \frac{16.7 \times 10^{-2}}{3.38} = 4.94 \times 10^{-2} m/s$$

$V_{moy} = \frac{s_{moy}}{t_{moy}} \quad \Rightarrow \frac{\Delta V}{V} = \frac{\Delta s}{s} + \frac{\delta t}{t}$ Donc:

$$\Delta V = V_{moy}\left(\frac{\Delta s}{s} + \frac{\delta t}{t}\right)$$

$$\Delta V_1 = V_{1\ moy}\left(\frac{\Delta s_1}{s_1} + \frac{\delta t_1}{t_1}\right) = 6.01 \times 10^{-2}\left(\frac{0.2 \times 10^{-2}}{27.3 \times 10^{-2}} + \frac{0.25}{4.54}\right) = 0.0037\ m/s$$

$$\Delta V_2 = V_{2\ moy}\left(\frac{\Delta s_2}{s_2} + \frac{\delta t_2}{t_2}\right) = 7.41 \times 10^{-2}\left(\frac{0.3 \times 10^{-2}}{41.1 \times 10^{-2}} + \frac{0.03}{5.54}\right) = 0.0009\ m/s$$

$$\Delta V_3 = V_{3\ moy}\left(\frac{\Delta s_3}{s_3} + \frac{\delta t_3}{t_3}\right) = 7.66 \times 10^{-2}\left(\frac{0.3 \times 10^{-2}}{48.0 \times 10^{-2}} + \frac{0.14}{6.26}\right) = 0.0021\ m/s$$

$$\Delta V_4 = V_{4\ moy}\left(\frac{\Delta s_4}{s_4} + \frac{\delta t_4}{t_4}\right) = 7.16 \times 10^{-2}\left(\frac{0.2 \times 10^{-2}}{37.9 \times 10^{-2}} + \frac{0.05}{5.29}\right) = 0.0010\ m/s$$

$$\Delta V_5 = V_{5\ moy}\left(\frac{\Delta s_5}{s_5} + \frac{\delta t_5}{t_5}\right) = 4.94 \times 10^{-2}\left(\frac{0.3 \times 10^{-2}}{16.7 \times 10^{-2}} + \frac{0.16}{3.38}\right) = 0.0032\ m/s$$

❖ En calcule "$\grave{t}$":

$$\grave{t} = t_{moy} + \frac{\Delta t_{moy}}{2}$$

$$\grave{t}_1 = t_{1\,moy} + \frac{\Delta t_{1\,moy}}{2} = 4.54 + \frac{0.055}{2} = 4.577s$$

$$\grave{t}_2 = t_{2\,moy} + \frac{\Delta t_{2\,moy}}{2} = 5.54 + \frac{0.039}{2} = 5.559s$$

$$\grave{t}_3 = t_{3\,moy} + \frac{\Delta t_{3\,moy}}{2} = 6.26 + \frac{0.035}{2} = 6.277s$$

$$\grave{t}_4 = t_{4\,moy} + \frac{\Delta t_{4\,moy}}{2} = 5.29 + \frac{0.040}{2} = 5.310s$$

$$\grave{t}_5 = t_{5\,moy} + \frac{\Delta t_{5\,moy}}{2} = 3.38 + \frac{0.070}{2} = 3.415s$$

❖ En calcule "$\Delta\grave{t}$":

$$\Delta\grave{t}_1 = \delta t_1 + \delta\Delta t_1 = 0.250 + 0.005 = 0.255s$$

$$\Delta\grave{t}_2 = \delta t_2 + \delta\Delta t_2 = 0.030 + 0.002 = 0.032s$$

$$\Delta\grave{t}_3 = \delta t_3 + \delta\Delta t_3 = 0.140 + 0.001 = 0.141s$$

$$\Delta\grave{t}_4 = \delta t_4 + \delta\Delta t_4 = 0.050 + 0.001 = 0.051s$$

$$\Delta\grave{t}_5 = \delta t_5 + \delta\Delta t_5 = 0.160 + 0.002 = 0.162s$$

❖ En calcule les vitesses instantanées.

$$V_{moy} = V_{inst}\left(t + \frac{\Delta t}{2}\right)$$

\\\

$$V_{inst} = \frac{V_{moy}}{\left(t + \frac{\Delta t}{2}\right)}$$

$$V_{1\ inst} = \frac{6.01 \times 10^{-2}}{(4.577)} = 0.0131\ m/s$$

$$V_{2\ inst} = \frac{7.41 \times 10^{-2}}{(5.559)} = 0.0133\ m/s$$

$$V_{3\ inst} = \frac{7.66 \times 10^{-2}}{(6.277)} = 0.0122\ m/s$$

$$V_{4\ inst} = \frac{7.16 \times 10^{-2}}{(5.310)} = 0.0134\ m/s$$

$$V_{5\ inst} = \frac{4.94 \times 10^{-2}}{(3.415)} = 0.0144\ m/s$$

- En trace le graphe $V = f(\dot{t})$.

On a dans le graphe $V = A.\dot{t}$

Et théoriquement $V = \frac{m.g}{m+\frac{I}{r^2}}\ .t$

Donc $A = \frac{m.g}{m+\frac{I}{r^2}}$

Calculer A_{min} et A_{max} :

$$A_{min} = \tan 41.80 = 0.89$$

$$A_{max} = \tan 53.04 = 1.32$$

Calculer I_{min} et I_{max} :

$$A_{max} = \frac{m.g}{m + \frac{I_{min}}{r^2}} \quad \Rightarrow I_{min} = r^2 m\left(\frac{g - A_{max}}{A_{max}}\right)$$

$$A_{min} = \frac{m.g}{m + \frac{I_{max}}{r^2}} \quad \Rightarrow I_{max} = r^2 m\left(\frac{g - A_{min}}{A_{min}}\right)$$

$$I_{min} = (0.25)^2(0.4365)\left(\frac{9.81 - 1.32}{1.32}\right) = 0.175\ kg/cm^2$$

$$I_{max} = (0.25)^2(0.4365)\left(\frac{9.81 - 0.89}{0.89}\right) = 0.273\ kg/cm^2$$

$$I_z = \frac{I_{max} + I_{min}}{2} = \frac{0.175 + 0.273}{2} = 0.224\ kg/cm^2 = 2240\ kg/m^2$$

$$\Delta I_z = \frac{I_{max} - I_{min}}{2} = \frac{0.273 - 0.175}{2} = 0.049\ kg/cm^2 = 490\ kg/m^2$$

- Déterminer les différentes énergies :

On a la relation suivante

$$E_T = E_{potentielle} + E_{translation} + E_{rotation}$$

$$E_T = m.\vec{g}.\vec{s} + \frac{1}{2}m\vec{v}^2 + \frac{1}{2}I_z\vec{\omega}^2$$

- ✓ En calcule l'énergie potentielle

$$E_{P\,1} = -m.g.s_{1\,moy} = -0.4365 \times 9.81 \times 27.3 \times 10^{-2} = -1.169\ J$$
$$E_{P\,2} = -m.g.s_{2\,moy} = -0.4365 \times 9.81 \times 41.1 \times 10^{-2} = -1.759\ J$$
$$E_{P\,3} = -m.g.s_{3\,moy} = -0.4365 \times 9.81 \times 48.0 \times 10^{-2} = -2.050\ J$$
$$E_{P\,4} = -m.g.s_{4\,moy} = -0.4365 \times 9.81 \times 37.9 \times 10^{-2} = -1.622\ J$$
$$E_{P\,5} = -m.g.s_{5\,moy} = -0.4365 \times 9.81 \times 16.7 \times 10^{-2} = -0.715\ J$$

- ✓ En calcule l'énergie de translation

$$E_{t\,1} = \frac{1}{2}mv_{1\,moy}^2 = \frac{1}{2}(0.4365)(6.01 \times 10^{-2}) = 0.0131\ J$$
$$E_{t\,2} = \frac{1}{2}mv_{2\,moy}^2 = \frac{1}{2}(0.4365)(7.41 \times 10^{-2}) = 0.0161\ J$$
$$E_{t\,3} = \frac{1}{2}mv_{3\,moy}^2 = \frac{1}{2}(0.4365)(7.66 \times 10^{-2}) = 0.0167\ J$$
$$E_{t\,4} = \frac{1}{2}mv_{4\,moy}^2 = \frac{1}{2}(0.4365)(7.16 \times 10^{-2}) = 0.0156\ J$$
$$E_{t\,5} = \frac{1}{2}mv_{5\,moy}^2 = \frac{1}{2}(0.4365)(4.94 \times 10^{-2}) = 0.0107\ J$$

- ✓ En calcule l'énergie de rotation

$$E_{R\,1} = \frac{1}{2}I_z\frac{V_1^2}{r^2} = \frac{1}{2}(0.224)\frac{(6.01\times10^{-2})}{(0.25)^2} = 0.107\ J$$
$$E_{R\,2} = \frac{1}{2}I_z\frac{V_2^2}{r^2} = \frac{1}{2}(0.224)\frac{(7.41\times10^{-2})}{(0.25)^2} = 0.132\ J$$
$$E_{R\,3} = \frac{1}{2}I_z\frac{V_3^2}{r^2} = \frac{1}{2}(0.224)\frac{(7.66\times10^{-2})}{(0.25)^2} = 0.137\ J$$
$$E_{R\,4} = \frac{1}{2}I_z\frac{V_4^2}{r^2} = \frac{1}{2}(0.224)\frac{(7.16\times10^{-2})}{(0.25)^2} = 0.128\ J$$

mécanique de l'énergie

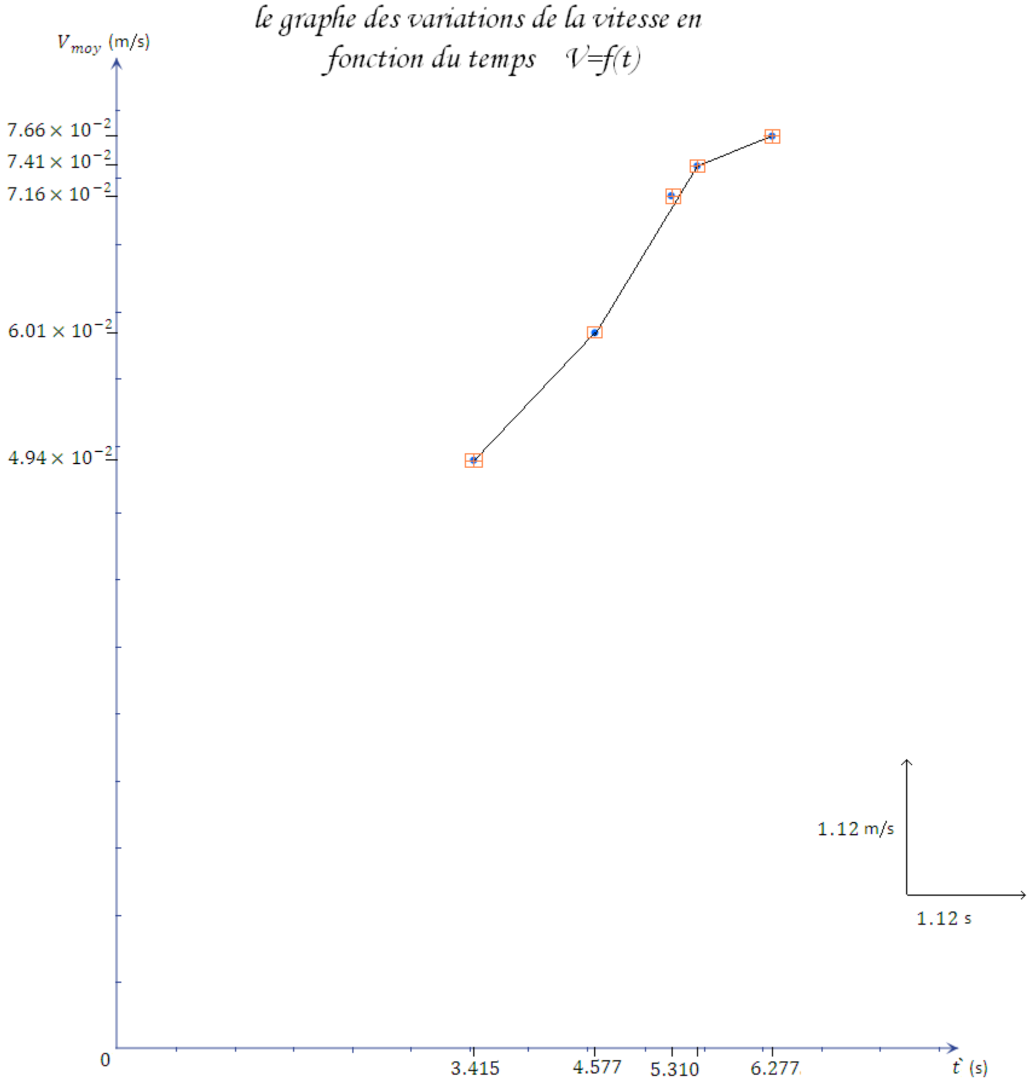
$$E_{R\,5} = \frac{1}{2}I_z\frac{V_5^2}{r^2} = \frac{1}{2}(0.224)\frac{(4.94\times10^{-2})}{(0.25)^2} = 0.088\ J$$

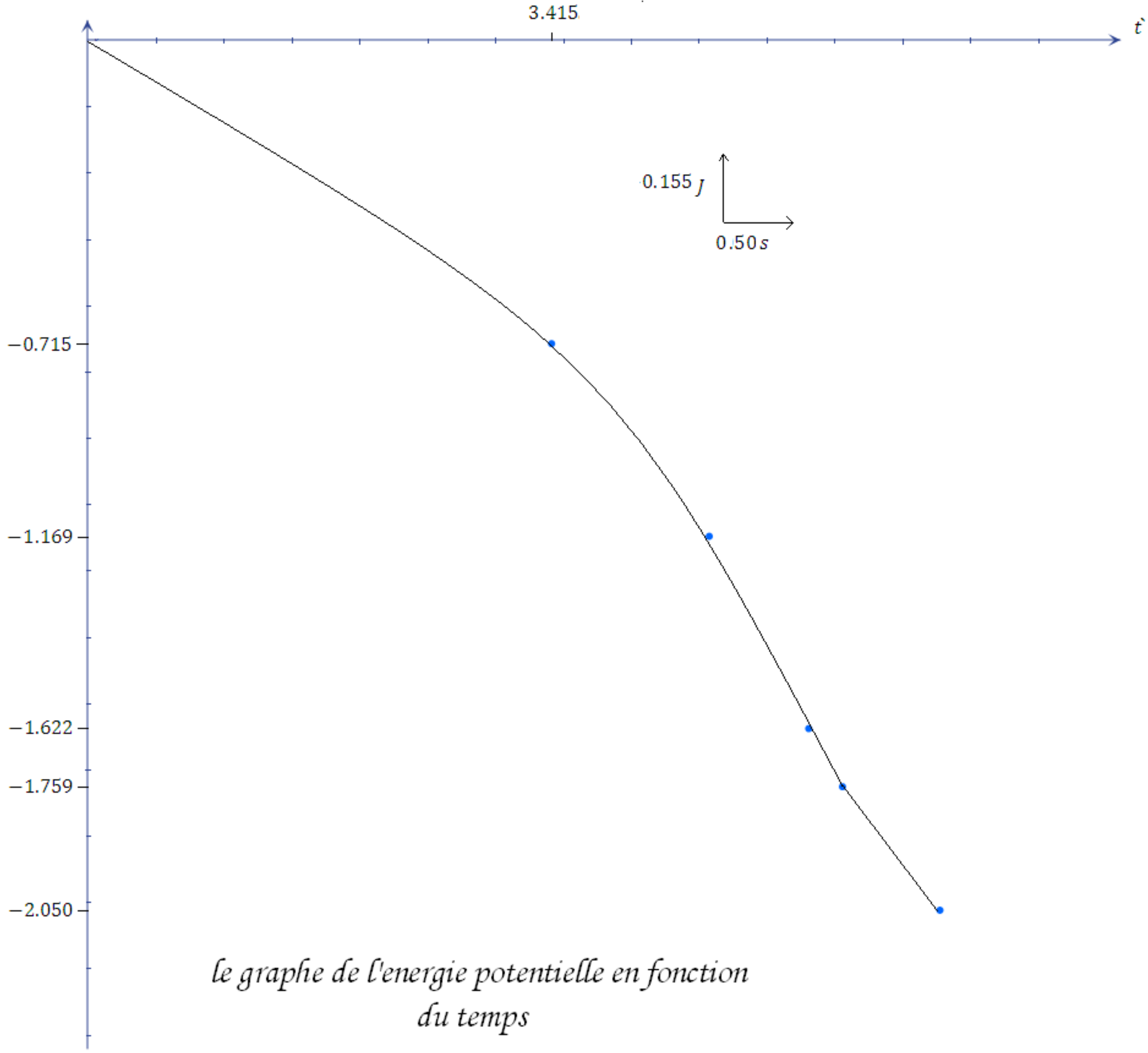
Conclusion

Après les étapes qu'on a suivi on conclue qu'on peut calculer avec la roue de maxwell plusieurs paramètres : moment d'inertie, énergie potentielle, énergie de translation et l'énergie de rotation, et en plus en vérifie la loi de conservation

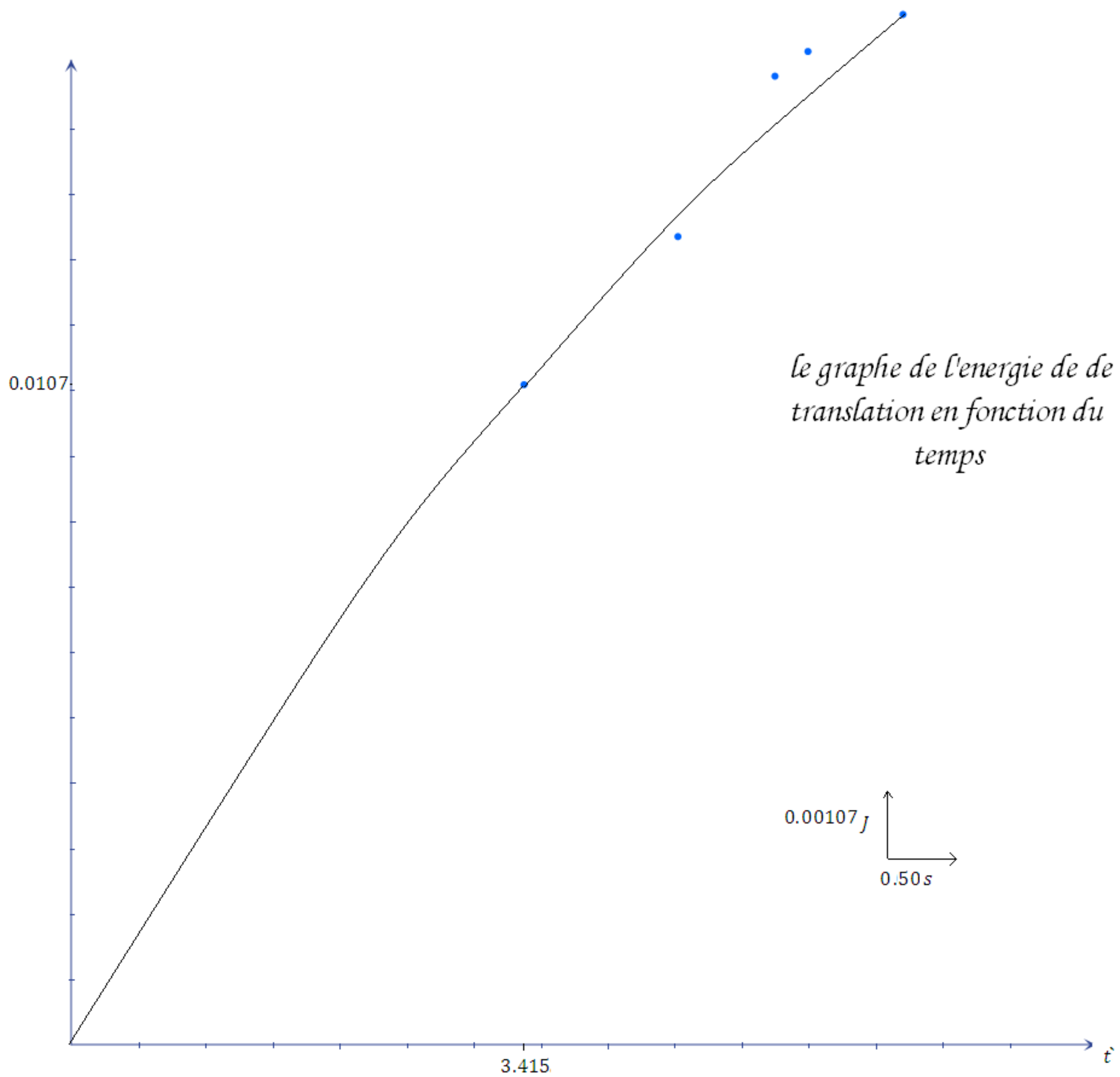
N°	S (m)	t (s)	Δt (s)	$s_{moy}\ (m)$	$\Delta s\ (m)$	$t_{moy}\ (s)$	$\delta t\ (s)$	$\Delta t_{moy}\ (s)$	$\delta \Delta t\ (s)$
1	27.2×10^{-2}	4.78	0.055	27.3×10^{-2}	0.2×10^{-2}	4.54	0.25	0.055	0.005
	27.4×10^{-2}	4.35	0.053						
	27.3×10^{-2}	4.47	0.059						
2	41.0×10^{-2}	5.53	0.039	41.1×10^{-2}	0.3×10^{-2}	5.54	0.03	0.039	0.002
	41.2×10^{-2}	5.54	0.040						
	41.3×10^{-2}	5.56	0.039						
3	48.2×10^{-2}	6.32	0.035	48.0×10^{-2}	0.3×10^{-2}	6.26	0.14	0.035	0.001
	47.9×10^{-2}	6.35	0.035						
	48.0×10^{-2}	6.13	0.035						
4	37.9×10^{-2}	5.33	0.040	37.9×10^{-2}	0.2×10^{-2}	5.29	0.05	0.040	0.001
	38.0×10^{-2}	5.30	0.040						
	38.0×10^{-2}	5.26	0.040						
5	16.9×10^{-2}	3.53	0.071	16.7×10^{-2}	0.3×10^{-2}	3.38	0.16	0.070	0.002
	16.7×10^{-2}	3.25	0.070						
	16.5×10^{-2}	3.37	0.070						

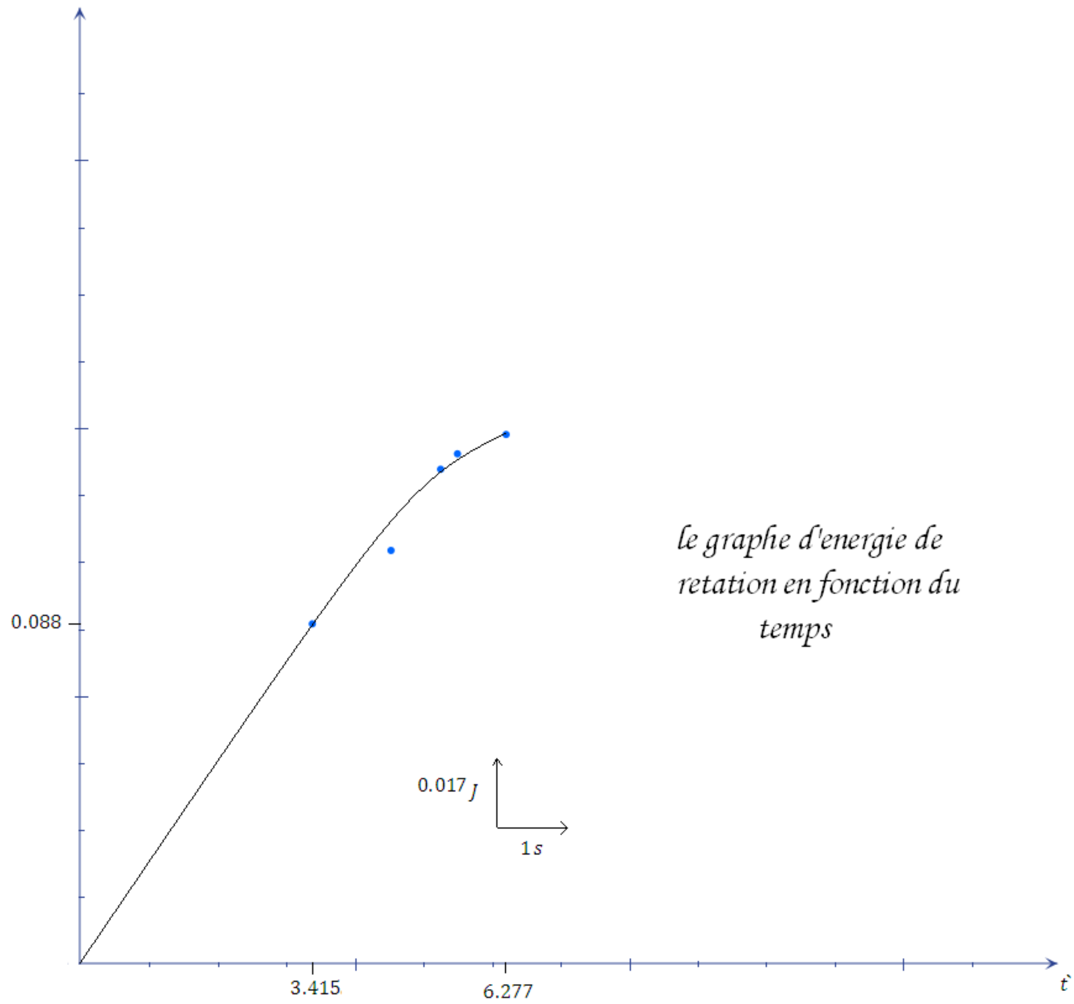
le graphe des variations de la vitesse en fonction du temps V=f(t)





le graphe de l'energie potentielle en fonction du temps


le graphe de l'energie de de translation en fonction du temps
0.0107
3.415
t
0.00107 J
0.50 s



le graphe d'energie de
retation en fonction du
temps
0.088
0.017 J
1 s
3.415
6.277
t`